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GROWTH PERFORMANCE OF ROSELLE (*HIBISCUS SABDARIFFA* L.) IN RESPONSE TO OIL PALM BY-PRODUCT MEDIA AND CONTROLLED RELEASE FERTILIZER

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Abstract

A study was carried out to optimize the best ratio of empty fruit bunch (EFB) of oil palm as soilless culture media for growth performance of roselle, to investigate the optimum level of slow release fertilizer for biomass production and to measure the interaction between different ratio of media and rate of fertilizer on growth of roselle. As treatment 4 different media (M_1 = Top soil, M_2 = 1 Top soil : 1 sand, M_3 = 2 Top soil : 1 EFB : 1 Sand, M_4 = 3 Top soil : 2 EFB : 1 Sand) and 4 different control released fertilizer (CRF) rates (F_1 = Control (80 kg/ha NPK), F_2 = 40 kg/ha Kamila, F_3 = 80 kg/ha Kamila and F_4 = 120 kg/ha Kamila) were applied in this experiment. Media treatment M_1 indicated a good response in number of branches, stem diameter, total number of calyxes and shoot dry weight compared to other 3 media. While M_3 and M_4 gave better respond on total leaf area and nutrient content (N, P and K) in plant tissue of roselle. Whereas for different rates of fertilizer applied, treatment F_3 (80 kg/ha Kamila CRF) exhibited the better performance on growth of roselle plants. Significant differences were observed for N, P and K nutrient uptake in fertilizer treatments compared to media treatments.

Introduction

Hibiscus sabdariffa L. known as roselle is an annual shrub of Malvaceae. It is a plant native to India and Malaysia also cultivated in tropical and subtropical areas of the world such as Sudan, Taiwan and Thailand (Mohamed *et al.* 2012, Appell 2003) with red or green inflated edible calyces (Babalola *et al.* 2004).

Demand has steadily increased for roselle over the past decades. Currently approximately 15,000 metric tons are entering in international trade each year (McCaleb 2000). Roselle has potential as an industrial crop that commonly used to make jellies, jams, food preserves and beverages.

Roselle can be commercially grown throughout the year. Many constraint limits of Roselle production include climatic variability, and limited suitable land (Fasoyiro *et al.* 2005). However, adaptation to the soil types as well as fertilization are the major concern which influence the quality of roselle for further processing product.

The application of slow release fertilizer can reduce surface run off of granule and chemical fertilizer (Li and Yang 2004). The application of slow release fertilizer at the rate of 80 kg/ha has been effectively absorbed by the plant at a slow rate.

Direct empty fruit bunch (EFB) of oil palm application is generally better for vegetative growth, palm nutrition and yield (Uwumarongie-Ilori *et al.* 2012). Considering environmental safety and economic way of fertilizer application this research was conducted to optimize the best

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ratio of EFB as soilless culture media for growth performance of roselle, to investigate the optimum level of slow release fertilizer for biomass production and to measure the interaction between different ratio of media and rate of fertilizer on growth of roselle.

Materials and Methods

The study was carried out in a rain shelter (11 m × 2 m) at Field 10, Universiti Putra Malaysia, to minimize rain drop impact to the plant. The 2 weeks old seedlings were transplanted into polybags (16 inch × 16 inch) maintaining 45 cm × 30 cm distances between polybags arranged in RCBD with four replications.The experiment was consisted of two factors included planting media and rate of slow release fertilizer. Three types of media including top soil, oil palm empty fruit bunch (EFB) and sand at different ratio were used in this study.

After transferring roselle seedlings into different media, the plant was fertilized with three different concentrations of slow release fertilizers (40, 80 and 120 kg/ha Kamila CRF). Kamila CRF has a composition of N : P : K : Mg (10 : 6 : 20 : 2) + 5% micronutrients, manufactured by Diversatech Fertilizer Sdn. Bhd., Bandar Baru Bangi, Selangor. Conventional rate of fertilization by using NPK Green and NPK Blue were used as a control. Kamila fertilizer was applied twice at 2nd and 8th weeks after transplanting. While, NPK fertilizer was applied at the interval of two weeks after transplanting. Two times watering was done manually, in the morning and in the evening throughout the entire study period. Manual weeding was practiced regularly in order to keep the soil mixture and the surrounding area free from unwanted plants. Plants were harvested on 12 weeks after transplanting.

The non-destructive data were collected at every 3 weeks interval on 3, 6, 9 and 12 weeks after transplanting (WAT) for the parameters including number of branches, number of calyx and stem diameter (cm). Destructive samplings data such as total leaf area (cm^2; using leaf area meter, LI-3100, USA), shoot dry weight (g), root dry weight (g), plant tissue analysis (N, P and K), soluble solid content (%, using pocket refracto meter) and pH (using pH meter) were determined at the end on 12 weeks after planting. Among the macronutrient elements, N and P were determined using Auto Analyzer (AA) whereas K was determined using Atomic Absorption Spectrometer (AAS), respectively.

The recorded data were subjected to analysis of variance (ANOVA) using SAS (SAS Institute Inc., Cary, NC, USA). Fisher's LSD were calculated following a significant ($p \leq 0.05$) F-test. All the assumptions of ANOVA were checked to ensure validity of statistical analysis.

Results and Discussion

There was significant ($p \leq 0.05$) difference on number of branches influenced by media mixture and rate of CRF on 3 to 12 WAT (Fig. 1). Results of study showed that M1 gave the highest number of branches (10) than the other treatments and M3 was the least one with only 7 branches. Results on the effect of different rate of fertilizer on number of branches from 3 to 12 WAT is presented in Fig. 2.

On third week, plants applied with treatment F1 and F2 exhibited significantly higher number of branches than F3 and F4. Number of branches were found higher in F1 (control) than F4 with 9 and 7 branches, respectively (Fig. 2).

Table 1 represented the stem diameter of roselle plants grown under different media mixture at 12 WAT. Plants grown under M1 and M4 media achieved higher stem diameter than M3 and M2 with the highest stem diameter (5.95 cm) on M1 and the lowest (4.83 cm) was in M2, respectively. Table 1 illustrated the effect of different media mixtures on total leaf area of roselle plants. Plants grown under media treatment M4 showed the highest total leaf area followed by M1, M3 and M2. On 12 WAT total numbers of calyx were significantly affected by the effect of different media mixtures (Table 1). Plants grown in M1 medium produced the highest total numbers of calyx followed by M4, M2 and M3 (Table 1). While, non-significant differences were found between F1 and F2 fertilizer treatments for total number of calyx on 12 WAT.

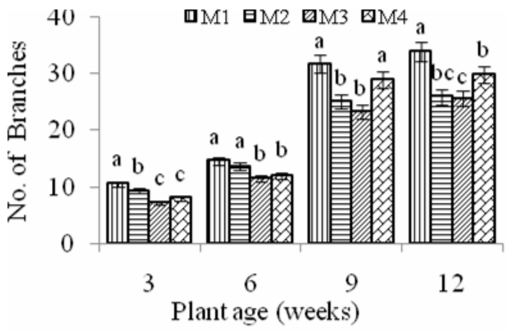

Fig. 1. Number of branches as influenced by medium mixture for 3 to 12 WAT.

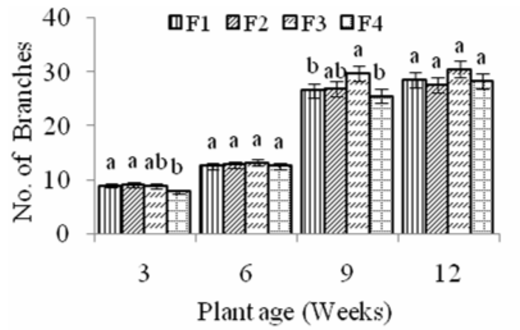

Fig. 2. Number of branches as influenced by different rate of controlled-released fertilizer for 3 to 12 WAT.

Table 1. Stem diameter, total leaf area and total number of calyx as influenced by media mixtures and controlled-released fertilizers rates on 12 WAT.

Treatments	Stem diameter (cm)	Total leaf area (cm^2)	Total number of calyx
M1	5.95a	5167.1ab	20.50a
M2	5.05bc	3366.4c	17.50ab
M3	4.83c	3838.6bc	14.13b
M4	5.64ab	5630.8a	19.56a
F1	5.28a	4060.38ab	17.44ab
F2	5.29a	3949.94b	17.38ab
F3	5.66a	5702.71a	20.94a
F4	5.22a	4289.87ab	15.94b

Mean values in each vertical column with different lower case letters are significantly different at $p \leq 0.05$. M1 = Top soil, M2 = 1 top soil : 1 sand, M3 = 2 top soil : 1 EFB : 1 sand, M4 = 3 top soil : 2 EFB : 1 sand and F1 = Control (80 kg/ha NPK), F2 = 40 kg/ha Kamila, F3 = 80 kg/ha Kamila and F4 = 120 kg/ha Kamila.

There was significant different for shoot dry weight influenced by different media mixtures on 12 WAT (Table 2). Plants shoot dry weight grown in M1 medium showed significantly higher (91.78 g) over other treatments followed by the lowest (47.11 g) in M3 medium. Fertilizer rates were also significantly affected the shoot dry weight with the highest shoot dry weight in F3 followed by F2, F4 and F1 (Table 2). Non-significant variation observed for the effect of different combinations of media on root dry weight of roselle plants on 12 WAT. Among all 4 treatments media the highest root dry weight was found in roselle plant grown in M1 and the lowest was obtained from M3 treatment media (Table 2). Previous study reported that, variation in chemical and physical properties as EFB as a media and the differences in plant sensitivity to defined root environmental condition might have contributed to the marked differences in some ornamental plants development (Yahya and Ismail 1996).

Total concentration of N in roselle leaf tissue significantly affected by the effect of different media treatments at 12 WAT (Table 3). Results showed that plants grown under M4 medium accumulated the highest N content than M1 medium, respectively. Furthermore, roselle plant tissues also showed significant differences among different rates of fertilizer treatment on N concentration at 12 WAT, where plants grown under F3 gave highest N content and the lowest was obtained by F1 treated plants (Table 3). Analysis of results revealed differences for P content in plant tissue of roselle as influenced by different media treatment at 12 WAT and plants grown in M4 was significant as compared to control (M1) (Table 3). Significant ($p \leq 0.05$) differences were observed among plant tissues grown under different media for K content on 12 WAT. Results of study showed that M3 is significantly different from other treatments.

Table 2. Shoot and root dry weight (g) as influenced by media mixtures (M) and different rates of controlled-released fertilizers (F) on 12 WAT.

Treatments	Shoot dry weight (g)	Root dry weight (g)
M1	91.78a	14.57a
M2	59.72bc	12.94a
M3	41.11c	11.54a
M4	73.37b	13.13a
F1	58.84b	10.71b
F2	62.25ab	12.2b
F3	77.93a	13.79ab
F4	72.96ab	15.49a

Mean values in each vertical column with different lower case letters are significantly different at $p \leq 0.05$. Abbreviations are same as shown in Table 1.

Table 3. Nitrogen (N), P and K contents as influenced by media mixtures and different rates of controlled-released fertilizers on 12 WAT.

Treatments	N content (%)	P content (%)	K content (%)
M1	1.44b	1.01b	0.094b
M2	2.36a	1.39a	0.149a
M3	2.02ab	1.42a	0.167a
M4	2.59a	1.49a	0.149a
F1	1.25b	1.04c	0.139b
F2	1.62b	1.22bc	0.102c
F3	2.80a	1.38ab	0.142b
F4	2.74a	1.66a	0.176a

Mean values in each vertical column with different lower case letters are significantly different at $p \leq 0.05$. Abbreviations are same as shown in Table 1.

Analysis of results indicated that differences on medium treatments significantly affected the pH of the calyx of roselle plants on 12 WAT. Plants grown under M3 medium expressed the highest mean of pH value and the lowest pH mean value was in M4. Roselle plants grown in M2 and M3 had significantly higher pH in calyx than plants grown in M1 and M4 media (Table 4). Results on SSC of roselle calyx indicated that there were no significant differences among media treatments having the highest SSC was in M4 compared to lowest in M3 (Table 4). While different rates of fertilizer treatments significantly affected the SSC of roselle calyx and the highest SSC was recorded in F1 followed by F2, F4 and F3. Overall, it seemed that the combination of different media mixtures did not affect the SSC in roselle calyx but fertilizer treatments F1 and F3 showed significant variation between them (Table 4).

Table 4. pH and soluble solid content as influenced by media mixtures and different rates of controlled-released fertilizers on 12 WAT.

Treatments	pH	Soluble solid content
M1	2.84*b*	5.44*a*
M2	2.89*ab*	4.91*a*
M3	2.94*a*	4.89*a*
M4	2.75*c*	5.71*a*
F1	2.89*a*	5.98*a*
F2	2.86*a*	5.19*ab*
F3	2.87*a*	4.70*b*
F4	2.81*a*	5.10*ab*

Mean values in each vertical column with different lower case letters are significantly different at $p \leq 0.05$. Abbreviations are same as shown in Table 1.

Results indicate that EFB and CRF can be potentially used as planting medium and fertilizer but there will be many aspects need to be considered such as the environmental factors which may affect the effectiveness of EFB towards plant growth and other quality measurement on roselle.

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